"EVALUATION OF MEDIAN NERVE IN CARPAL TUNNEL SYNDROME BY HIGH FREQUENCY ULTRASOUND & COLOUR DOPPLER IN COMPARISON WITH NERVE CONDUCTION STUDIES.

Dissertation submitted for

M.D. DEGREE EXAMINATION

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GOVERNMENT GENERAL HOSPITAL

CHENNAI – 600 003

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CHENNAI – 600 032

APRIL 2011

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DECLARATION

I **Dr.K.GEETHA,** solemnly declare that this dissertation entitled, **"EVALUATION OF MEDIAN NERVE IN CARPAL TUNNEL SYNDROME BY HIGH FREQUENCY ULTRASOUND & COLOUR DOPPLER IN COMPARISON WITH NERVE CONDUCTION STUDIES"** is a bonafide work done by me at the Barnard Institute of Radiology, Madras Medical College and Government General Hospital during the period 2008 – 2010 under the guidance and supervision of the Director, Barnard Institute of Radiology of Madras Medical College and Government General Hospital, Professor **K. Vanitha, M.D.,D.M.R.D.,D.R.M.,** This dissertation is submitted to The Tamil Nadu Dr. M.G.R Medical University, towards partial fulfillment of requirement for the award of **M.D. Degree Radiodiagnosis.**

Place : Chennai

Date: 30.11.10

Dr.K.GEETHA

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CONTENTS

INSTITUTIONAL ETHICAL COMMITTEE
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L.Dis.No.14597/ME5/Ethics Dean/MMC/2010 Dated : 12.05.2010

Title of the work : "Evaluation of Median Nerve in Carpel Tunnel Syndrome by High frequency Ultrasound and Doppler."

Principal Investigator : Dr. K. Geetha.
Designation : PG in MD Radio Diagnosis.
Department :
Madras Medical College & GGH, Ch-3.

The request for an approval from the Institutional Ethical Committee (IEC) was considered on the IEC meeting held on 12th May 2010 at 2.p.m in Pharmacology Seminar Hall, Madras Medical College, Chennai -3

The members of the Committee, the Secretary and the Chairman are pleased to approve the proposed work mentioned above, submitted by the principal investigator.

The Principal investigator and their team are directed to adhere to the guidelines given below:

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Consent Form

சுய ஒப்புதல் படிவம்

ஆய்வு செய்யப்படும் தலைப்பு

எண்ணை மற்றும் அதிநீர்கைஎளி உபயோகிப்பதின் மூலம் கார்பன் டைஆக்சைடின் உள்ள மீடியன் நரம்பின் தன்மையை அறிதல்

பர்னார்டு கதிரியியல் துறை	:	அரசு பொது மருத்துவமனை, சென்னை
பங்கு பெறுபவரின் பெயர்	:	
பங்கு பெறுபவரின் எண்	:	
பங்கு பெறுவர் இதனை (✓) குறிக்கவும்	:	

மேலே குறிப்பிட்டுள்ள மருத்துவ ஆய்வின் விவரங்கள் எனக்கு விளக்கப்பட்டது. என்னுடைய சந்தேகங்களை கேட்கவும், அதற்கான தகுந்த விளக்கங்களை பெறவும் வாய்ப்பளிக்கப்பட்டுள்ளது என அறிந்து கொண்டேன். ( )

நான் இவ்வாய்வில் தன்னிச்சையாக தான் பங்கேற்கிறேன். எந்த காரணத்தினாலோ எந்த சட்ட சிக்கலுமில்லாமல் நான் இவ்வாய்வில் இருந்து விலகி கொள்ளலாம் என்றும் அறிந்தும் கொண்டேன். ( )

இந்த ஆய்வு சம்பந்தமாகவோ, இதை சார்ந்த மேலும் ஆய்வு மேற்கொள்ளும் போதும் இந்த ஆய்வில் பங்குபெறும் மருத்துவர் என்னுடைய மருத்துவ அறிக்கைகளை பார்ப்பதற்கு எனது அனுமதி தேவையில்லை என அறிந்து கொள்கிறேன். ( )

இந்த ஆய்வின் மூலம் கிடைக்கும் தகவலையோ, முடிவையோ பயன்படுத்திக் கொள்ள மறுக்கமாட்டேன். ( )

இந்த ஆய்வில் பங்குகொள்ள ஒப்புக்கொள்கிறேன். எனக்கு கொடுக்கப்பட்ட அறிவுரைகளின்படி நடந்து கொள்வதுடன் இந்த ஆய்வை மேற்கொள்ளும் மருத்துவ அணிக்கு உண்மையாக இருப்பேன் என்றும் உறுதியளிக்கிறேன். என் உடல் நலம் பாதிக்கப்பட்டாலோ அல்லது எதிர்பாராத வழக்கத்திற்கு மாறான நோய்குறி தென்பட்டாரோ உடனே இதை மருத்துவ அலுவலரிடம் தெரியப்படுத்த வேண்டும் என உறுதி அளிக்கிறேன். ( )

பங்கேற்பவரின் கையொப்பம் ..... இடம் ..... தேதி
கட்டை விரல் ரேகை

பங்கேற்பவரின் பெயர் மற்றும் விலாசம் .....

ஆய்வாளரின் கையொப்பம் ..... இடம் ..... தேதி
ஆய்வாளரின் பெயர் .....

INTRODUCTION

Carpal tunnel syndrome, a most common peripheral entrapment neuropathy of the upper extremity, is recognized as one of the most important causes of workplace morbidity . Diagnosis of carpal tunnel syndrome is usually based on a combination of clinical signs such as the Tinel sign (tapping over the median nerve producing dysesthesias) and the Phalen sign (wrist flexion producing dysesthesias), and nerve conduction studies. However, the clinical signs are moderately sensitive and specific , and false-negative and false-positive results of nerve conduction studies have been reported.

High-resolution ultrasound and MRI have emerged as feasible, noninvasive imaging tools for evaluating the median nerve in the carpal tunnel. Both techniques permit perception of nerve compression characteristics, including altered signal, increased cross-sectional area, flattening of the median nerve, and bowing of the flexor retinaculum. The sensitivity and specificity of these diagnostic features vary widely among published studies , and the critical cutoff value for the nerve cross-sectional area, at which nerve entrapment can be diagnosed, varies considerably, from more than 0.09 to 0.15 cm^2.

Like peripheral nerves, the median nerve is well vascularized with epineural and endoneural microvasculature .Nerve compression caused by elevated pressure in the carpal tunnel is believed to provoke a three-stage process that is initiated with venous congestion of the median nerve followed by nerve edema and then by impairment of the venous and arterial blood supplies . Investigators in recent studies evaluated the blood flow in the median nerve and emphasized the vascular cause of carpal tunnel syndrome. Furthermore, the vascular mechanism of carpal tunnel syndrome was also reporte as the explanation for abnormal enhancement of the median nerve on dynamic contrast-enhanced MRI.

To our knowledge, the usefulness of High-resolution sonography with color Doppler in detecting intraneural circulatory disturbance in patients with suspected carpal tunnel syndrome has not yet been investigated in comparison with nerve conduction study, although color Doppler sonography has been used to evaluate the presence of a persistent median artery in the carpal tunnel and a variety of peripheral nerve abnormalities .

The purpose of this study was to assess the accuracy of high frequency ultrasound & colour Doppler evaluation of median nerve

in Carpal Tunnel Syndrome in comparison with Nerve conduction study . We also assessed the accuracy of gray-scale sonography findings in detecting median nerve entrapment and attempted to determine the best independent sonographic indicator of carpal tunnel syndrome.

Recent advances in High-frequency and Duplex Ultrasound like better post-processing capability, transducer technology, image resolution, signal strength and spectral analysis capabilities have improved its ability to visualize and grade abnormalities, thus extending the scope for non-invasive ,less expensive ,real time assessment of median nerve in Carpal Tunnel Syndrome .

AIM OF THE STUDY

- This prospective study aims to evaluate the median nerve in Carpal Tunnel Syndrome by high frequency ultrasound & colour Doppler in comparison with Nerve conduction study .

CARPAL TUNNEL SYNDROME

ANATOMY OF CARPAL TUNNEL (Fig 1)

The median nerve lies within the carpal tunnel and is often located immediately beneath the retinaculum, just to the radial side of the superficial row of flexor digitorum tendons (Figs 1,3,4,5).

SONOHISTOLOGY OF PERIPHERAL NERVE (MEDIAN NERVE)

The basic units of the peripheral nerve consist of a neural fiber embedded in endoneurium. Because the endoneurium is too thin to reflect the sound beam, it is hypoechogenic at high-resolution US. The neural fascicle consists of several neural fibers and is embedded in a capsule called perineurium. This capsule consists of connective tissue, vessels, and lymphatic ducts and is thick enough to reflect the sound beam, resulting in hyperechoic lines at high-resolution US. The trunk of the peripheral nerve consists of several neural fascicles and is embedded in a thicker membrane called epineurium, which is seen as bold echogenic lines at high-resolution US.

Therefore, at high-resolution US the peripheral nerve is seen as several parallel echogenic lines within two bold echogenic lines in longitudinal sections and as a reticular pattern in transverse sections (Fig 2) On transverse sonograms, the nerve appears elliptic in outline and seems to become progressively flatter as it passes through the canal.

CARPAL TUNNEL SYNDROME

DEFINITION

Carpal tunnel syndrome is the most common peripheral neuropathy of the upper extremity and results from compression of the median nerve beneath the transverse carpal ligament. This syndrome most often affects middle-aged women.

CLINICAL FEATURES

Patients with carpal tunnel syndrome experience a burning wrist pain ,which may radiate either proximally to the shoulder and neck region or distally into the fingers.

An insidious onset of paresthesia or numbness in the thumb, index (second) finger, middle (third) finger, and the radial aspect of the fourth finger often is described; this pattern of numbness corresponds with the innervation pattern of the median nerve at the hand. Symptoms often are worse at night and are exacerbated by repetitive flexion and extension of the wrist, strenuous gripping, or exposure to vibration. In the later stages, patients experience clumsiness of the hand because of thenar muscle weakness .

A physical examination with percussion may evoke tingling (the Tinel sign) in the median nerve at the wrist. Sensory nerve function may be abnormal and is easily evaluated by testing with a light touch or pin-prick. Results of the Phalen maneuver (extreme flexion of the wrist to test for dysesthesia), Flick test (shaking of the hand to see whether symptoms are relieved), and percussion (for the Tinel sign) are frequently positive in patients with carpal tunnel syndrome. In severe or chronic cases, muscle atrophy of the thenar eminence may be present .

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CAUSES OF CARPAL TUNNEL SYNDROME

Carpal tunnel syndrome may result from any process that causes compression of the median nerve in the carpal tunnel **.**

TABLE 1
CAUSES OF COMPRESSION OF THE MEDIAN NERVE IN THE CARPAL TUNNEL

Congenital	**:**	Anomalous flexor tendons
		Congenitally small carpal canal
		Proximal lumbrical muscle insertion
Inflammatory	**:**	Connective tissue disease
		Gout or pseudogout
		Nonspecific flexor tenosynovitis
		Rheumatoid arthritis
Infectious	**:**	Lyme disease
		Mycobacterial infection
		Septic arthritis
Idiopathic		
Metabolic and Endocrine Processes :		Acromegaly
		Amyloidosis
		Diabetes
		Hypothyroidism
		Pregnancy
Trauma		
Mass Lesions	**:**	Ganglion,
		Lipoma,
		Neurofibroma,
		Fibrolipomatous Hamartoma
Increased canal volume :		Congestive heart failure
		Edema
		Obesity
Repetitive Use		

INDICATIONS FOR IMAGING

The differential diagnosis in patients with carpal tunnel syndrome includes lesions of the central nervous system, cervical radiculopathy, brachial plexopathy, ulnar neuropathy at the elbow, and other focal neuropathies of the upper extremity, including proximal median nerve lesions. So these causes should be ruled out for the effective management of carpal tunnel syndrome .

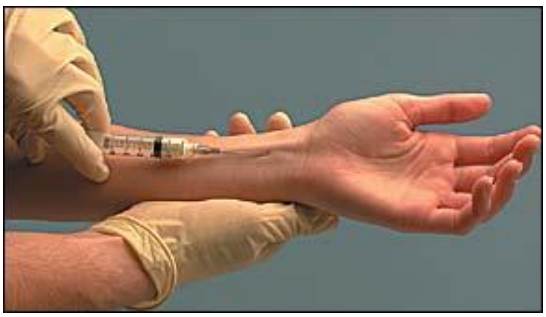
MANAGEMENT OF CARPAL TUNNEL SYNDROME

After ruling out tumors and trauma as a cause of carpal tunnel syndrome, the main recommended treatments are local corticosteroid injection, splinting (immobilizing braces), oral corticosteroids and ultrasound treatment often with various stretching exercises .

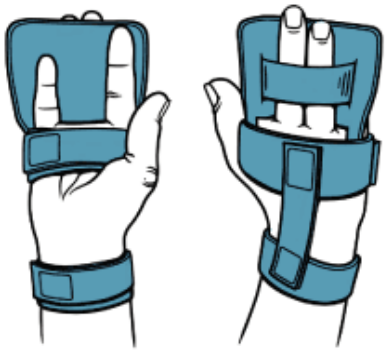
The treatment should be switched when the current treatment fails to resolve the symptoms within 2 to 7 weeks.

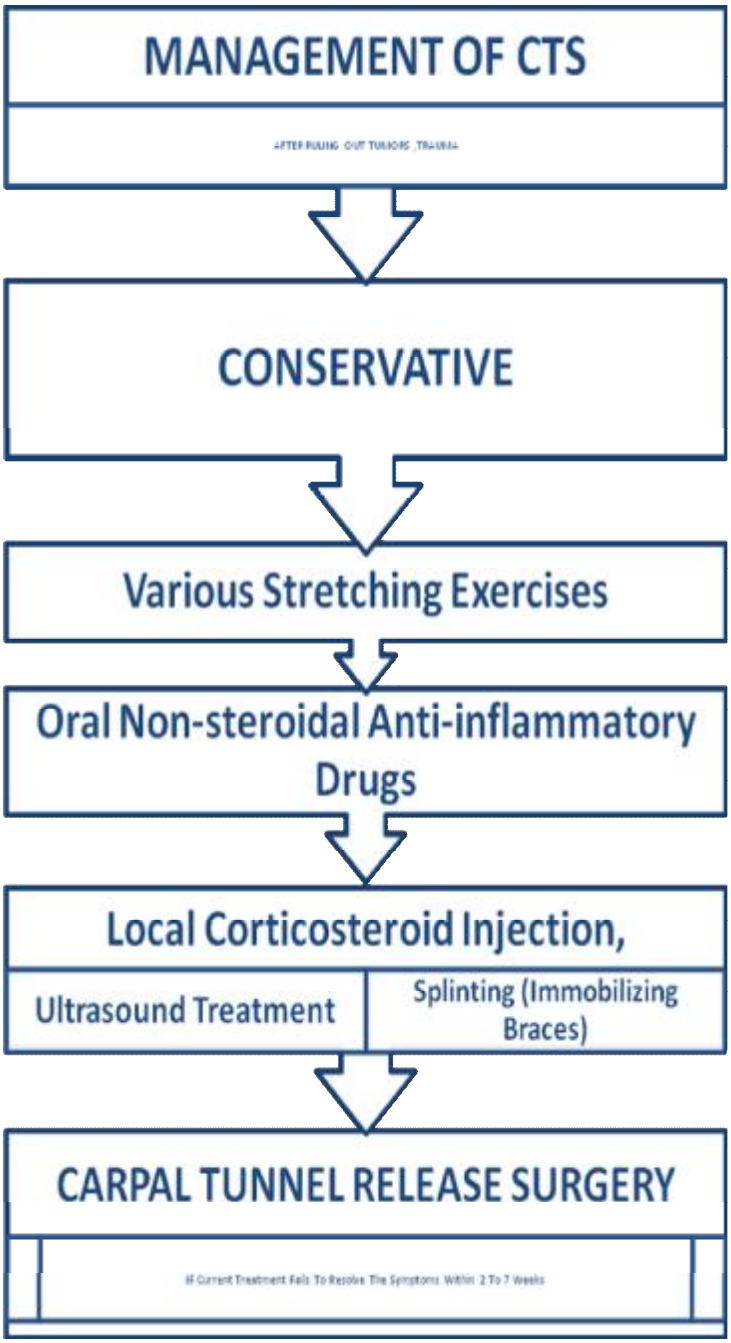
Early surgery with carpal tunnel release is indicated where there is clinical evidence of median nerve denervation or the patient elects to proceed directly to surgical treatment.

Local Corticosteroid Injection



Wrist splint





Ref: American Academy of Orthopaedic Surgeon ,American Academy of Neurology.

IMAGING MODALITIES

The options for imaging are as follows:

a. NERVE CONDUCTION STUDY

b. HIGH FREQUENCY ULTRASOUND

c. DUPLEX ULTRASOUND

d. MAGNETIC RESONANCE IMAGING

a. NERVE CONDUCTION STUDY

Nerve Conduction Study is still considered the gold standard against which other techniques are compared. The diagnosis of carpal tunnel syndrome was indicated by the patient's history (nocturnal hand discomfort and sensory impairment in the distributionof the median nerve) and clinical examinations (Tinel and Phalen signs). Clinical diagnosis was confirmed by electrodiagnostic testing. Abnormal nerve conduction was defined as a reduction in median nerve sensory conduction velocity of more than 49msec and prolongation of the distal motor latency of more than 4.4 msec without abnormalities in the ulnar nerve or proximal median nerve parameters.

Limitations

- Ø Though noninvasive, test may discomfortable and painful.
- Ø Conduction velocity less in obese individuals.

b. HIGH FREQUENCY AND DOPPLER ULTRASOUND

Duplex scanning combines both B-mode ultrasound and colour doppler ultrasound to provide both anatomical and hemodynamic (functional) information. Recent advances in gray scale imaging including compounding, speckle reduction techniques gives excellent high resolution images.

Advantages

- widely available
- inexpensive
- noninvasive
- nonionizing
- does not require nephrotoxic contrast.

Limitations

- Operator-dependent limitations
- Operator independent limitations
  - Ø Ultrasound is a focal imaging tool, and cannot define co-existent extrinsic pathology completely or provide global imaging of the nervous system.

C. MAGNETIC RESONANCE IMAGING

MR imaging of the wrist has been performed with magnetic field strengths that range from 1.5 to 3.0 T and with dedicated surface coils . The imaging protocol included T1-weighted spin-echo (SE) sequences in the coronal and transverse planes and two coronal intermediate-weighted fast SE sequences with different repetition and echo times (first sequence: repetition time msec/echo time msec, 4000/45; second sequence: 1800/17). The second intermediate-weighted fast SE sequence (1800/17) was performed with and without fat saturation. Finally, a coronal three-dimensional fast field-echo (FFE) sequence was performed. Finally.T-1 Fat sat post contrast study done.High contrast and high spatial resolution are important prerequisites for accurate MR imaging of the wrist.

Disadvantages

- Time consuming
- High cost
- Sensitive to patient motion artefacts
- Claustrophobia
- Metallic implants (such as pacemakers) or foreign bodies may preclude the examination or produce magnetic susceptibility artefacts**.**

REVIEW OF LITERATURE

Although a large number of studies were conducted in the past to evaluate the efficacy of High-resolution sonography in diagnosing carpal tunnel syndrome ,only very few studies done to evaluate accuracy of high frequency ultrasound & colour Doppler evaluation of median nerve in Carpal Tunnel Syndrome in comparison with Nerve conduction study .

Y. M. El Miedany, et al studied Seventy-eight patients with CTS and 78 asymptomatic controls were assessed and underwent ultrasonography of the wrists. All patients and controls completed a self-administered questionnaire. Electrophysiological testing was done for all patients and control subjects. Data from the patient and the control groups were compared to determine the diagnostic relations in patients with CTS and the grade of severity.

Results showed a high degree of correlation between the conduction abnormalities of the median nerve as detected by electrodiagnostic tests, self-administered assessment and the measurement of the cross-sectional area of the nerve by US ($P<0.05$). Various levels of disease severity could also be illustrated by US, giving confident results for diagnosis, treatment planning and following the

patients with CTS. In 16 patients (17%) tenosynovitis/localized swelling in the tendons in the carpal tunnel was the primary cause of CTS. A cut-off point of 10 mm^2 for the mean cross-sectional area of the median nerve was found to be the upper limit for normal values. Based on the results of this study, an algorithm for evaluation and management of CTS has been suggested.

They concluded that High-frequency US examination of the median nerve and measurement of its cross-sectional area should be strongly considered as a new alternative diagnostic modality for the evaluation of CTS. In addition to being of high diagnostic accuracy it is able to define the cause of nerve compression and aids treatment planning; US also provides a reliable method for following the response to therapy.

April 2007- L H Visser et al ,studied 207 patients with possible CTS underwent high-resolution sonography and EMG. The diagnosis of CTS was based on clinical signs and symptoms. The cross-sectional area of the median nerve at the carpal tunnel inlet and at the distal one-third level of the forearm was assessed by an investigator, blinded to the clinical and EMG data. Normal sonographic values were obtained from 137 controls. All patients and 40 controls underwent a standardised nerve conduction study. The kappa coefficient was used to evaluate the relationship between sonography, EMG and clinical diagnosis.

Results showed cross sectional area at the distal one-third of the forearm was not significantly different between the controls and patients ($p=0.59$) Whereas the cross-sectional area at the carpal tunnel inlet was significantly increased in the patient group ($p<0.0001$). The kappa coefficient for EMG using the median-ulnar distal sensory latency difference versus clinical evaluation was 0.64 and, for sonography, this coefficient was 0.69; these were not statistically different ($p = 0.37$).

Combining the two tests resulted in a kappa coefficient of 0.72, which was not significantly different from sonography alone ($p = 0.73$). They Concluded that in patients with a clinical diagnosis of CTS, the accuracy of sonography is similar to that for EMG. Sonography is probably preferable because it is painless, easily accessible and preferred by the patients.

Mallouhi et al ,studied 206 wrists in 151 patients with a clinical suspicionof carpal tunnel syndrome were examined with high-resolution sonography using a 7–15-MHz linear array transducer. The presence of median nerve swelling, edema, and flattening and increased bowing of the flexor retinaculum was evaluated with gray-scale sonography,and the presence of nerve hypervascularization was evaluated with color Doppler .

Carpal tunnel syndrome was confirmed in 172 wrists at nerve conduction studies. A median nerve cross-sectional area of at least 0.11 cm^2 was calculated as a definition of median nerve swelling. In comparison with nerve conduction studies, nerve swelling showed the highest accuracy (91%) among gray-scale sonography criteria, and the presence of intraneural hypervascularization showed the highest accuracy (95%) among all sonography criteria. Logistic regression analysis showed that nerve hypervascularization was the only variable that independently predicted median nerve entrapment (odds ratio, 16.4; 95% confidence interval, 8.7-31.1; p <0.001

Mauro Mondelli et al studied 85patients (70 women and 15 men, mean age 46.8 years) reported symptoms compatible with classic/probable CTS. The protocol included NCV of the median and ulnar nerves (distal motor latency [DML], sensory conduction velocity [SCV] from the third [M3 SCV] and fourth fingers [M4 SCV] to the wrist for the median nerve); electrophysiologic severity scale; self-administered Levine/Boston questionnaire (BQ); and cross-sectional area (CSA) measurement of the nerve at the tunnel inlet (CSA-I), at the middle (CSA-M), and at the outlet (CSA-O). Relationship between age, body mass index, duration of symptoms, CSAs, NCV, electrophysiologic severity scale, and BQ scores was calculated. Concordance between CSAs and NCV, sensitivity of NCV and US was

also evaluated. They found the mean values of CSA-I, CSA-M, and CSA-O were 10.3, 9.8, and 8.7 mm^2, respectively. Relationships were found between CSA-I and M3 SCV ($r = -0.45$), M4 SCV ($r = -0.56$), and median nerve DML ($r = 0.29$). Anomalous CSA-I, CSA-M, and CSA-O were found in 48, 25, and 26 patients, respectively; 55 (64.7%) had ≥1 abnormal CSA. NCV abnormalities were found in 67%. The sensitivity increased to 76.5% if US and NCV were considered together. The highest concordance to detect absence/presence of abnormalities was between CSA-I and NCV (77.6%; $\kappa = 0.52$).

They concluded that in mild cases of CTS, US did not detect more anomalies than NCV and vice versa, and no anomalies were detected with either diagnostic instrument in 23.5% of mild cases.

Klauser et al studied 100 wrists of 68 consecutive patients with CTS (16 men, 52 women; mean age, 57.9 years; range, 25–85 years) and 93 wrists of 58 healthy volunteers (16 male, 42 female; mean age, 55.1 years; range, 17–85 years) were examined with ultrasonography (US).Electrodiagnostic test results confirmed the diagnosis of CTS in all 68 patients. The US examiner was blinded to these test results. The CSA of the median nerve was measured at the carpal tunnel and proximal levels, and the difference between CSAc and CSAp (ΔCSA) was calculated for each wrist.

They found mean CSAc in healthy volunteers (9.0 mm^2) was smaller than that in patients (16.8 mm^2, $P < .01$). The mean ΔCSA was smaller in asymptomatic wrists (0.25 mm^2) than in CTS-affected wrists (7.4 mm^2, $P < .01$). Receiver operating characteristic analysis revealed a diagnostic advantage to using the ΔCSA rather than the CSAc ($P = .036$). Use of a ΔCSA threshold of 2 mm^2 yielded the greatest sensitivity (99%) and specificity (100%) for the diagnosis of CTS. Receiver operating characteristic analysis revealed improved accuracy in the diagnosis of CTS determined with the ΔCSA compared with the accuracy of the diagnosis determined with the CSAc.

Wong et al studied133 patients suspected of having CTS were referred to a teaching hospital between October 2001 and June 2002 for electrodiagnostic study. One hundred twenty patients (98 women, 22 men; mean age, 49 years; range, 19–83 years) underwent sonography within 1 week after electrodiagnostic study. Radiologist was blinded to electrodiagnostic study results. Seventy-five patients had bilateral symptoms; 23 patients, right-hand symptoms; and 22 patients, left-hand symptoms (total, 195 symptomatic hands). Cross-sectional area of median nerve was measured at three levels: immediately proximal to carpal tunnel inlet, at carpal tunnel inlet, and at carpal tunnel outlet. Flexor retinaculum was used as a landmark to margins of carpal tunnel.

Optimal thresholdlevels (determined with classification and regression tree analysis) for areas proximal to and at tunnel inlet and at tunnel outlet were used to discriminate between patients with and patients without disease. Sensitivity, specificity, and false-positive and false-negative rates were derived on the basis of final diagnosis, which was determined with clinical history and electrodiagnostic study results as reference standard.

The results were for right hands, sonography had sensitivity of 94% (66 of 70); specificity, 65% (17 of 26); false-positive rate, 12% (nine of 75); and false-negative rate, 19% (four of 21) (cutoff, 0.09 cm^2 proximal to tunnel inlet and 0.12 cm^2 at tunnel outlet). For left hands, sensitivity was 83% (53 of 64); specificity, 73% (24 of 33); false-positive rate, 15% (nine of 62); and false-negative rate, 31% (11 of 35) (cutoff, 0.10 cm^2 proximal to tunnel inlet).Sonography is comparable to electrodiagnostic study in diagnosis of CTS and should be considered as initial test of choice for patients suspected of having CTS.

Hashemi et al (Sep 2009) studied 100 wrists of 50 consecutive patients referred to 22-Bahman Hospital with suspected diagnosis of CTS during 2007 to 2008. The patients suspicious for CTS were referred for electrophysiologic studies. Then immediately the patients underwent sonography of the median nerve.

Results from the 100 wrists (50 patients) studied, CTS was diagnosed in 53 cases. Most of the cases were in females (91%) of them 90% were homemakers. The peak age distribution was in the range of 40 to 49 years. The chief complaint in all cases was pain and paresthesia. There was no predisposing factor for most cases; however, 6% were affected by diabetes, 6% by hypertriglyceridemia, and 2% by hypothyroidism. The Tinel test and Phalen test were positive in 31% and 33% of the cases, respectively, and 42% of the cases were positive for both or one of the Tinel and Phalen tests. Comparison of the ultrasonography and electrophysiologic findings showed a sensitivity of 90%, specificity of 74%, and accuracy of 83% for ultrasound in CTS diagnosis. The study findings indicated an accuracy of 77% for clinical tests and 83% for sonography against electrophysiologic studies as the gold standard. Considering the acceptable sensitivity and specificity of ultrasonography, it can be recommended as a noninvasive method for diagnosis of CTS.

MATERIALS AND METHODS

STUDY POPULATION

The study group includes a total of 108 wrists in 72 patients with unilateral or bilateral carpal tunnel syndrome - who have come to the department of radiology for wrist ultrasound.

PERIOD OF STUDY : MAY 2008 – MAY 2010

INCLUSION CRITERIA

Age Group – Any Age Group

Clinical Suspicion Of Carpal Tunnel Syndrome

Unilateral Or Bilateral

EXCLUSION CRITERIA

Patients with Tumors in wrist

Patients with Trauma to wrist

Patients with wrist surgery.

DATA ACQUISITION

SONOGRAPHY TECHNIQUE

High frequency ultrasound and Doppler sonography examinations were performed using a Siemens Acuson Antares Ultrasound machine (fig.6) band width frequency transducer with a range of 7-13MHz for median nerve evaluation at Carpal Tunnel.

Patients were seated in front of the examiner (Fig 7 b) with hands are kept on the lap of the patient over the pillow in the supine and neutral wrist position.

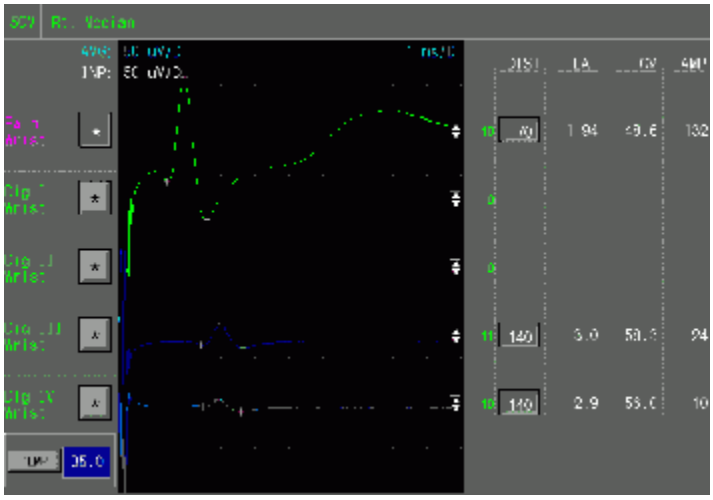
TECHNIQUE: (Fig 7)

Systematic Scanning with very little pressure and by applying thick layer of gel (gel standoff pad)the course of the median nerve in and proximal to the carpal tunnel was carefully scanned with the transducer in both the transverse and longitudinal planes to investigate the presence of median nerve compression criteria. Sonographic examinations included measurements of diameters and cross-sectional areas of the median nerve proximal to the carpal tunnel, and at the tunnel inlet by using digital calipers at the time of the examination. The maximum height of the retinaculum was measured above a line subtended between its radial and the ulnar carpal attachments .

Color Doppler sonograms were acquired after modifying the color window dimensions to include the median nerve. Color Doppler sonography settings were adjusted for investigating low-flow vessels. Pulse repetition frequency was set at low(800-900) Hz,and Doppler gain was adjusted to the maximum level that does not produce clutter. Sonograms were digitally saved. In order to eliminate interobserver variation, all Doppler studies were done by the same radiologist.

Gold Standard- Nerve Conduction Study

The diagnosis of carpal tunnel syndrome was indicated by the patient's history (nocturnal hand discomfortand sensory impairment in the distributionof the median nerve) and clinical examinations (Tinel and Phalen signs). Clinical diagnosis was confirmed by nerve conduction study.



Abnormal nerve conduction was defined as a reduction in median nerve sensory conduction velocity of more than 49msec and prolongation of the distal motor latency of more than 4.4msec without abnormalities in the ulnar.

IMAGE ANALYSIS

Median nerve involvement was characterized by evaluating five sonography features on a 2-point ordinal scale: present or absent , blinded to nerve conduction study.

First, the presence of nerve edema was assessed. The normal median nerve is a bundle of hypoechoic nerve fascicles surrounded by hyperechoic epineural connective tissue, all of which is encased in the hyperechoic perineural sheath .Nerve edema alters the signal produced by nervecomponents and results in increased hypoechoic signal of the nerve.

Next, the presence of nerve swelling and nerve flattening were assessed. Nerve swelling was defined as an enlargement of the cross-sectional area of the nerve to 0.11 cm2 or more within or proximal to the carpal tunnel. The cross-sectional area of the nerve was defined as the area of the nerve bundles in the perineural fibrous tissue. All measurements were rounded to the nearest 0.01 cm2. Nerve flattening was defined as a decrease in the minor axis combined with an increase in the major axis of the median nerve in the carpal tunnel with a flattening ratio (nerve's major to its minor axis) of atleast 3. The prospectively measured values for cross-sectional area and major and

minor axes of the median nerve were used in this study. The maximal value of the nerve cross-sectional area (in or proximal to the carpal tunnel) was used to judge the presence or absence of nerve swelling, and maximal alteration of the major and minor axes of the median nerve, within the carpal tunnel, was used to determine the presence or absence of nerve flattening.

In addition, the presence of increased palmar bowing of the flexor retinaculum was determined to be displacement of the palmar apex of the retinaculum2 mm or more from the straight line between its attachments to the trapezium tubercle and the hamate hook or the displacement of the palmar apex of the retinaculum 2.5 mm or more from the straight line joining the inferior most visualized part of retinaculum.

Finally, color Doppler sonograms were evaluated to determine the presence of any intraneural vascular structures not related to a persistent median artery.

RESULTS AND ANALYSIS

The study involved 72 patients (60 women, 12men). Of these patients, majority(50) were above 40 years of age. Age greater than 40 years were significantly associated with carpal tunnel syndrome. Multivariate stepwise logistic regression analysis of nerve cross-sectional area determined the value 0.11 cm2 as the threshold value that independently predicts carpal tunnel syndrome. Therefore, nerve swelling was defined, in this study, as an enlargement of nerve cross-sectional area to at least 0.11 cm2.Nerve conduction studies of 108 wrists in72 patients revealed 83 wrists with carpal tunnel syndrome. Gray-scale sonography revealed at least one abnormal finding in 88 wrists .Color Doppler sonography depicted intraneural blood vessels in 14 wrists and correctly identified carpal tunnel syndrome in 14. Of 108 wrists with carpal tunnel syndrome, 11met only one sonography criterion for carpal tunnel syndrome—that is, nerve swelling in eighteen wrists, and nerve flattening and edema in four respectively. Examination of the multivariate stepwise logistic regression analysis of sonography criteria showed that nerve swelling was the only gray-scale sonography variable that was independently predictive of the electrophysiology outcome ($p < 0.001$) for each 1%increase in nerve cross-sectional area. Color doppler sonography has highest(100%) specificity and positive

predictive value but lowest (17%) sensitivity. Though all sonographic predictors of carpal tunnel syndrome (presence of nerve edema, nerve swelling, nerve flattening, bowing of the flexor retinaculum, or intraneural hypervascularization) shows statistically significant p value of less than 0.05 nerve swelling has highely significant p value of 0.0001 and yielded best detectability.

STATISTICAL ANALYSIS

Data entry procedures and statistical analysis were performed with a statistical software system(SPSS Version 11.0.0 [SPSS] for Windows [Microsoft]). In the analysis, stepwise logistic regression analysis was used first to determine the threshold value of the median nerve's cross-sectional area that would be predictive of carpal tunnel syndrome.

Different values for nerve cross-sectional area ranging from 0.07 to 0.15 cm2 were evaluated as independent covariates. Then sensitivity, specificity,accuracy, and positive and negative predictive values were calculated on a per-wrist basis—that is, the ability to correctly identify wrists with carpal tunnel syndrome. Finally, multivariate stepwise logistic regression analysis was performed to determine the best sonographic predictors of carpal tunnel syndrome (presence of nerve edema, nerve swelling, nerve flattening, bowing of the flexor retinaculum,or intraneural hypervascularization).

Variables were retained in the logistic model if they contributed to the explanatory power of the regression equation ($p < 0.10$). The results were presented as an odds ratio and 95% confidence interva(CI). All p values were two-sided; a p value of less than 0.05 was considered

statistically significant. Though all sonographic predictors of carpal tunnel syndrome (presence of nerve edema, nerve swelling, nerve flattening, bowing of the flexor retinaculum,or intraneural hypervascularization) shows statistically significant *p* value of lessthan 0.05 nerve swelling has highely significant *p* value of 0.0001.

Logistic Regression Analysis

Case Processing Summary

Unweighted Cases(a)		**N**	**Percent**
Selected Cases	Included in Analysis	108	100.0
	Missing Cases	0	.0
	Total	108	100.0
Unselected Cases		0	.0
Total		108	100.0

a If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	**Internal Value**
Absent	0
Present	1

Classification Table(a,b)

Observed			**Predicted**		
			NCS		**Percentage Correct**
			Absent	**Present**	
Step 0	NCS	Absent	0	25	.0
		Present	0	83	100.0
	Overall Percentage				76.9

a Constant is included in the model.

b The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	1.200	.228	27.665	1	.000	3.320

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	NER_EDM	4.849	1	.028
		NER_SWEL	14.063	1	.000
		NER_FLA	8.197	1	.004
		PFR	4.435	1	.035
		NV	4.845	1	.028
	Overall Statistics		21.777	5	.001

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	27.571	5	.000
	Block	27.571	5	.000
	Model	27.571	5	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	89.298	.225	.341

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	4.510	6	.608

Contingency Table for Hosmer and Lemeshow Test

		NCS = Absent		NCS = Present		Total
		Observed	Expected	Observed	Expected	
Step 1	1	13	14.358	13	11.642	26
	2	5	3.301	6	7.699	11
	3	5	3.644	10	11.356	15
	4	0	1.678	11	9.322	11
	5	1	.771	8	8.229	9
	6	1	.999	12	12.001	13
	7	0	.248	11	10.752	11
	8	0	.000	12	12.000	12

Classification Table(a)

Observed			Predicted		
			NCS		Percentage Correct
			Absent	Present	
Step 1	NCS	Absent	14	11	56.0
		Present	13	70	84.3
	Overall Percentage				77.8

a The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1(a)	NER_EDM	1.081	.719	2.259	1	.133	2.947
	NER_SWEL	1.346	.567	5.642	1	.018	3.843
	NER_FLA	1.231	.716	2.958	1	.085	3.425
	PFR	.178	.772	.053	1	.817	1.195
	NV	19.865	9832.859	.000	1	.998	424011223.187
	Constant	-.210	.361	.337	1	.562	.811

a Variable(s) entered on step 1: NER_EDM, NER_SWEL, NER_FLA, PFR, NV.

Nerve Conduction Study * Nerve Edema

Crosstab

			Nerve Edema		Total
			Present	Absent	
NCS	Present	Count	29	54	83
		% within NCS	34.9%	65.1%	100.0%
		% within Nerve Edema	90.6%	71.1%	76.9%
	Absent	Count	3	22	25
		% within NCS	12.0%	88.0%	100.0%
		% within Nerve Edema	9.4%	28.9%	23.1%
Total		Count	32	76	108
		% within NCS	29.6%	70.4%	100.0%
		% within Nerve Edema	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.849(b)	1	.028		
Continuity Correction(a)	3.811	1	.051		
Likelihood Ratio	5.501	1	.019		
Fisher's Exact Test				.044	.021
Linear-by-Linear Association	4.804	1	.028		
N of Valid Cases	108				

a Computed only for a 2x2 table

b 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.41.

Nerve Conduction Study * Nerve Swelling

Crosstab

			Nerve Swelling		Total
			Present	**Absent**	
NCS	Present	Count	68	15	83
		% within NCS	82%	18%	100.0%
		% within Nerve Swelling	94.%	6%	76.9%
	Absent	Count	4	21	25
		% within NCS	16.0%	84.0%	100.0%
		% within Nerve Swelling	42%	58%	23.1%
Total		Count	72	36	108
		% within NCS	66%	34%	100.0%
		% within Nerve Swelling	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	14.063(b)	1	.000		
Continuity Correction(a)	12.369	1	.000		
Likelihood Ratio	13.987	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	13.932	1	.000		
N of Valid Cases	108				

a Computed only for a 2x2 table

b 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.95.

Nerve Conduction Study * Nerve Flattening

Crosstab

			Nerve Flattening		Total
			Present	Absent	
NCS	Present	Count	36	47	83
		% within NCS	43.4%	56.6%	100.0%
		% within Nerve Flattening	92.3%	68.1%	76.9%
	Absent	Count	3	22	25
		% within NCS	12.0%	88.0%	100.0%
		% within Nerve Flattening	7.7%	31.9%	23.1%
Total		Count	39	69	108
		% within NCS	36.1%	63.9%	100.0%
		% within Nerve Flattening	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	8.197(b)	1	.004		
Continuity Correction(a)	6.894	1	.009		
Likelihood Ratio	9.329	1	.002		
Fisher's Exact Test				.004	003
Linear-by-Linear Association	8.121	1	.004		
N of Valid Cases	108				

a Computed only for a 2x2 table

b 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.03.

Nerve Conduction Study * Palmar Bowing of Flexar Retinaculum

Crosstab

			PFR		Total
			Present	Absent	
NCS	Present	Count	28	55	83
		% within NCS	33.7%	66.3%	100.0%
		% within PFR	90.3%	71.4%	76.9%
	Absent	Count	3	22	25
		% within NCS	12.0%	88.0%	100.0%
		% within PFR	9.7%	28.6%	23.1%
Total		Count	31	77	108
		% within NCS	28.7%	71.3%	100.0%
		% within PFR	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	4.435(b)	1	.035		
Continuity Correction(a)	3.437	1	.064		
Likelihood Ratio	5.023	1	.025		
Fisher's Exact Test				.044	.027
Linear-by-Linear Association	4.394	1	.036		
N of Valid Cases	108				

a Computed only for a 2x2 table

b 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.18.

Nerve Conduction Study * Nerve Vascularity

Crosstab

			Nerve Vascularity		Total
			Present	Absent	
NCS	Present	Count	14	69	83
		% within NCS	16.9%	83.1%	100.0%
		% within Nerve Vascularity	100.0%	73.4%	76.9%
	Absent	Count	0	25	25
		% within NCS	.0%	100.0%	100.0%
		% within Nerve Vascularity	.0%	26.6%	23.1%
Total		Count	14	94	108
		% within NCS	13.0%	87.0%	100.0%
		% within Nerve Vascularity	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.845 (b)	1	.028		
Continuity Correction(a)	3.465	1	.063		
Likelihood Ratio	7.980	1	.005		
Fisher's Exact Test				.037	.019
Linear-by-Linear Association	4.800	1	.028		
N of Valid Cases	108				

a Computed only for a 2x2 table

b 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.24.

DISCUSSION

This study involved 72 patients of 108wrists with unilateral or bilateral carpal tunnel syndrome - who have come to the department of radiology for wrist ultrasound.

Accurate detection of median nerve entrapment in patients with a clinical suspicion of carpal tunnel syndrome is essential, especially if surgery is contemplated. MRI and sonography have both been advocated as noninvasive diagnostic techniques for the detection of median nerve entrapment. Both provide direct visualization of the median nerve within and proximal to the flexor retinaculum, enabling morphologic assessment of the median nerve, including nerve swelling, edema, flattening, and bowing of the flexor retinaculum.

A number of authors have reported the accuracy of sonography criteria of median nerve entrapment [17–23],and several studies have addressed the quantification of the nerve cross-sectional area and its role in diagnosing carpal tunnel syndrome [17–19, 24]. Review of these studies reveals a number of discrepancies in the accuracy of various sonography criteria in diagnosing carpal tunnel syndrome. Although almost all published studies on the sonographic diagnosis of carpal tunnel syndrome agree that

nerve swelling is the main sonography criterion but the critical threshold for nerve cross-sectional area differ considerably among those studies. The sensitivity of nerve swelling ranged from 57% to 89% [17–20,22, 23,35], and the nerve cross-sectional area indicating carpal tunnel syndrome ranged from 0.09 to 0.15 cm^2 [18,24] . The role of retinaculum bowing and nerve flattening also varied among studies, with sensitivities of 45-81% [17,23] and 38-65% respectively. The accuracy of nerve edema in the sonographic diagnosis of carpal tunnel syndrome, to our knowledge, has not yet been reported.

This study evaluates the accuracy of five sonographic signs in predicting carpal tunnel syndrome—namely, the four gray-scale sonography morphologic features and intraneural hypervascularization of the median nerve.

Gray-scale and color Doppler sonography findings were compared with the widely used standard of reference—nerve conduction studies—in all patients to determine the reviewer-dependent accuracy of sonography in the diagnosis of carpal tunnel syndrome.

Comparison of findings of sonography and nerve conduction studies showed that nerve swelling yielded the best detectability of carpal tunnel syndrome. Nerve swelling shows a higher accuracy in

detecting carpal tunnel syndrome than other sonographic signs because of a substantial increase in sensitivity, specificity and also increase in negative predictive values. As opposed to gray-scale sonography, color Doppler sonography has highest specificity and positive predictive value but low sensitivity.

Table showing Sensitivity, Specificity PPV, NPV of Sonographic predictors

Sonographic Predictors	Sensitivity(%)	Specificity(%)	Positive predictive value(%)	Negative predictive value(%)
Nerve Edema	35%	88%	91%	29%
Nerve Swelling	82%	84%	94%	58%
Nerve Flattening	44%	88%	92%	32%
Palmar Bowing Flex.Ret.	34%	88%	90%	28%
Nerve Vascularity	17%	100%	100%	29%

Because of its comprehensive perceptibility of the carpal tunnel and its high detectability of criteria associated with carpal tunnel syndrome, MRI is considered the noninvasive examination of choice for evaluating the carpal tunnel and in particular the median nerve. However, MRI is cost-intensive, time consuming and may not always be as readily available as sonography. Improved sonography resolution may provide a further advantage over MRI. Like gray-scale sonography criteria, MRI features that indicate carpal tunnel syndrome are not consistently proven in published studies. Several studies found that nerve swelling, nerve flattening, and increased signal intensity correlate well with carpal tunnel syndrome, whereas other studies emphasized the role of palmar bowing of the flexor retinaculum and nerve swelling in the diagnosis. In a recent study, Jarvik et al. [40] reported a high sensitivity (91%) combined, however, with a low specificity (38%) of increased signal intensity of the median nerve in detecting carpal tunnelsyndrome.

Furthermore, MRI may require the IV injection of contrast material to evaluate the vitality of the median nerve, and sonography does not require contrast material. Color Doppler

sonography, a convenient integral adjunct to gray-scale sonography, tends to show the pathologic intraneural vasculature, thus permitting recognition of hypervascularization in the median nerve in some cases. Generating a reliable color Doppler sonogram of the median nerve can be achieved, in our experience, by limiting the Doppler window to the median nerve and maximizing Doppler gain to a level that does not produce clutter that hampers the image. Furthermore, it is important to scan the median nerve without applying any pressure to the median nerve through the transducer, which may cause compression of the tiny intraneural vascular structures and render them occult.

In this study, the sensitivity of nerve edema and that of bowing of the retinaculum in the detection of carpal tunnel syndrome were concordant with previous studies, although the sensitivity of nerve swelling and nerve flattening was somewhat higher. All patients in our study were examined with a linear transducer with a 7-15-MHz frequency using sonographic compound imaging and a gel pad on the patient's forearm. Although it was not formally assessed in this study, our impression is that the resulting high-quality, high-resolution sonograms enabled precise measurements of median nerve cross-sectional area and therefore better characterization of nerve involvement.

A main limitation of our investigation is only patients with nerve conduction studies were included. Although carpal tunnel syndrome is a common health problem, the ratio of carpal tunnel syndrome patients in our investigation may not correspond to that in society. However, the study results are in concordance with data reporting the peak prevalence of carpal tunnel syndrome in women older than 40 years .Another limitation of this study is the lack of a quantitative analysis of the number or density of abnormal intraneural blood vessels. A further limitation of our study is that quantitative analysis of nerve measurements was not performed on a segmental basis—that is, proximal to the carpal tunnel, at the pisiform level, and at the hamate level. Rather, only data on maximal alteration were included in the statistical analysis.

CONCLUSION

High Frequency with Doppler Ultrasound provides high-resolution, precise anatomical and physiological information of the median nerve in carpal tunnel.

In our study ,all the sonographic criteria(presence of nerve edema, nerve swelling, nerve flattening, bowing of the flexor retinaculum, or intraneural hypervascularization) shows significant detectability of carpal tunnel syndrome.

Comparison of all sonographic criteria with nerve conduction studies showed that nerve swelling yielded the best detectability of carpal tunnel syndrome.

Sonography is comparable to nerve conduction study in diagnosis of CTS and should be considered as initial test of choice for patients suspected of having CTS.

Hence, High Frequency with Doppler Ultrasound is a safe, rapid, inexpensive, non-invasive, easily available diagnostic tool with high diagnostic accuracy and is indispensable in the investigation of clinically suspected carpal tunnel syndrome .

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ABBREVIATIONS

CTS - Carpal Tunnel Syndrome

NCS - Nerve Conduction Study

USG - Ultrasonography

MRI - Magnetic resonance imaging

PPV - Positive Predictive Value

NPV - Negative Predictive Value

PROFORMA

HIGH FREQUENCY AND DOPPLER STUDY OF WRIST-MEDIAN NERVE IN CARPAL TUNNEL SYNDROME

NAME: **AGE/ SEX :** **STUDY NO :**

CLINICAL HISTORY:

SONOGRAPHIC CRITERIA	RIGHT		LEFT	
	PRESENT	ABSENT	PRESENT	ABSENT
NERVE SWELLING (CROSS –SECTIONAL AREA OF > 0.11CM2)				
NERVE EDEMA				
NERVE FLATTENING				
PALMAR BOWING OF FLEXOR RETINACULUM				
NERVE VASCULARITY				

MASTER CHART

SNO	AGE	SEX	SONOGRAPHIC CRITERIA					
			Nerve Edema	Nerve Swelling	Nerve Flattening	Palmar Bowing Of FR	Nerve Vascularity	Nerve Conduction Study
1	43	F	P	P	P	P	A	P
2	43	F	P	P	A	A	A	P
3	38	F	P	P	P	P	A	P
4	38	F	A	P	P	A	A	P
5	56	M	A	P	A	P	A	P
6	43	F	P	A	A	A	A	P
7	43	F	P	P	P	P	P	P
8	53	F	P	P	P	A	A	P
9	32	F	P	P	P	P	A	P
10	32	F	A	P	P	A	A	P
11	47	F	A	P	P	A	A	P
12	47	F	A	P	A	A	A	P
13	58	M	A	P	P	P	A	P
14	38	F	P	P	A	A	P	P
15	54	M	A	P	P	A	A	P
16	54	M	P	P	A	A	A	A
17	64	F	A	P	A	P	A	P
18	55	F	A	P	P	A	P	P
19	55	F	A	A	A	A	A	A
20	54	F	P	P	A	P	A	P
21	54	F	P	P	P	A	P	P
22	44	F	A	A	A	A	A	A
23	44	F	A	P	A	A	A	P
24	48	F	A	P	P	A	A	P
25	37	F	P	P	A	A	A	P
26	42	M	A	P	A	P	P	P
27	44	F	A	A	A	A	A	A
28	37	F	A	P	A	A	A	A
29	37	F	A	P	A	P	A	P

30	43	M	A	P	P	P	A	P
31	59	F	P	A	A	A	A	A
32	59	F	A	P	A	A	A	P
33	28	F	A	P	P	P	A	P
34	28	F	A	P	P	A	A	A
35	34	F	A	P	P	P	A	P
36	34	F	A	P	P	A	P	P
37	54	F	A	A	P	P	A	P
38	37	F	A	P	A	A	A	P
39	33	F	A	A	A	A	A	A
40	57	F	P	P	P	P	A	P
41	35	F	A	P	A	A	A	P
42	43	F	P	P	A	A	A	P
43	43	F	P	P	A	A	A	P
44	56	M	A	P	A	A	A	A
45	56	M	P	P	P	P	P	P
46	65	F	A	P	A	A	A	P
47	65	F	A	A	A	A	P	P
48	34	F	A	A	A	A	A	P
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50	48	M	P	P	A	P	A	P
51	48	M	A	A	P	P	A	A
52	33	F	A	A	A	A	A	P
53	47	M	P	P	P	A	A	P
54	47	M	P	A	P	A	A	P
55	35	F	P	P	A	A	P	P
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57	31	F	A	A	A	A	A	A
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78	58	F	P	P	P	P	A	P
79	64	F	P	A	A	A	A	P
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81	55	F	A	A	A	A	A	A
82	54	F	P	P	A	P	P	P
83	44	M	A	A	A	A	A	A
84	44	M	A	P	A	A	A	P
85	48	F	A	P	P	P	A	P
86	44	F	A	A	P	A	A	P
87	36	F	A	A	A	A	A	A
88	36	F	A	P	A	A	A	P
89	47	F	A	A	A	A	A	A
90	47	F	A	A	A	A	A	A
91	37	F	A	P	A	A	A	P
92	48	F	A	P	A	A	P	P
93	48	F	A	A	A	A	A	A
94	59	F	P	P	A	A	A	P
95	28	F	A	P	A	A	A	P

96	36	F	P	P	A	P	A	P
97	36	F	A	P	A	A	A	P
98	38	F	P	A	A	P	A	A
99	38	F	A	P	P	A	P	P
100	44	F	A	P	P	A	A	P
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`104	43	F	A	P	A	A	A	P
105	40	F	A	P	P	P	A	P
106	53	M	A	A	A	P	A	A
107	53	M	A	A	A	A	P	P
108	42	F	A	P	A	A	A	P

Introduction

Aim of the Study

Review of Literature

Materials and Methods

Results and Data Analysis

Discussion

Conclusion

CARPAL TUNNEL SYNDROME

Annexures

Bibliography

Fig.1 SONOGRAPHY OF NORMAL MEDIAN NERVE IN CARPAL TUNNEL.

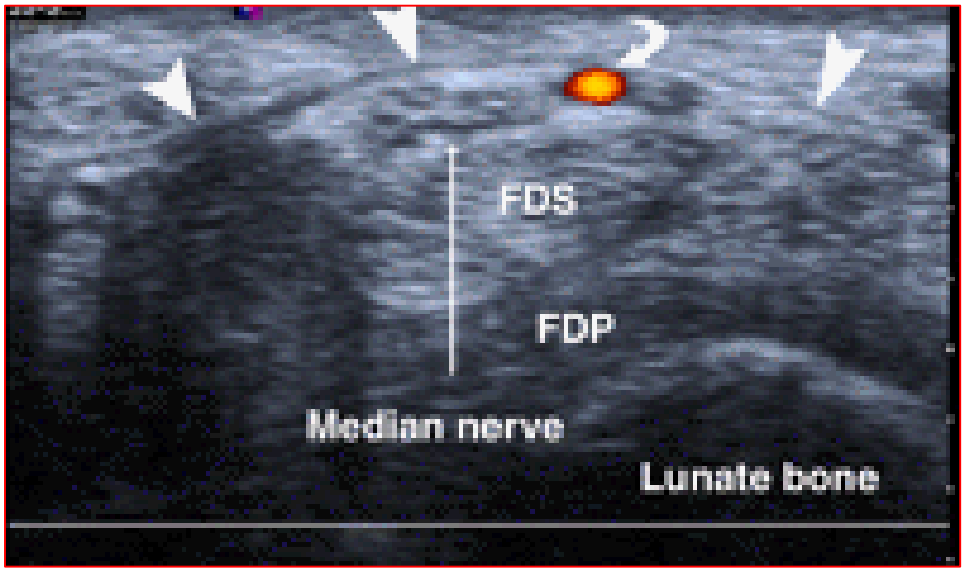


Fig.2

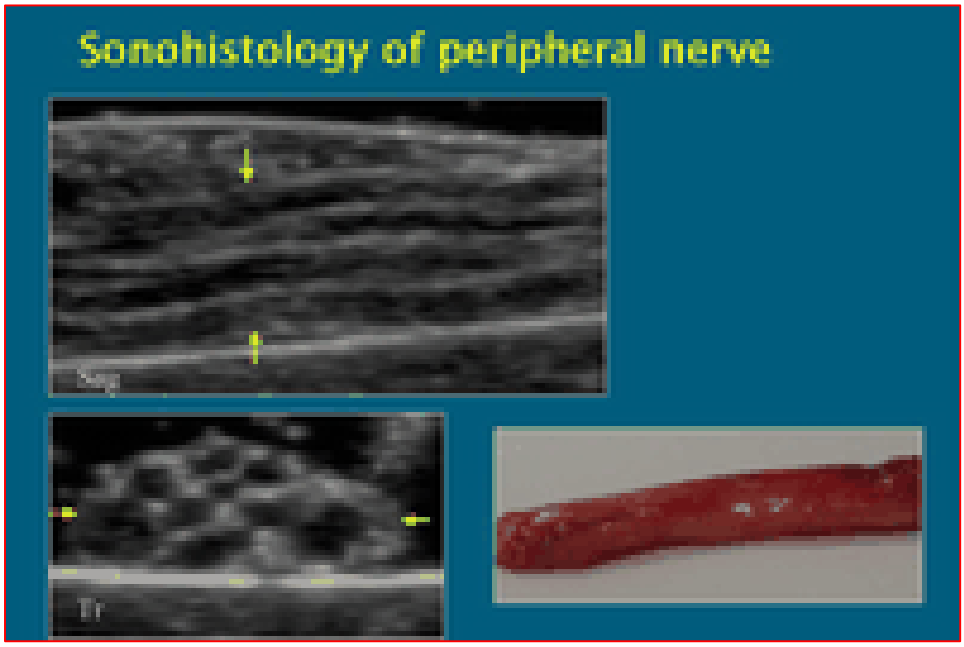


Fig 3: PROXIMAL AXIAL VIEW OF CARPAL TUNNEL

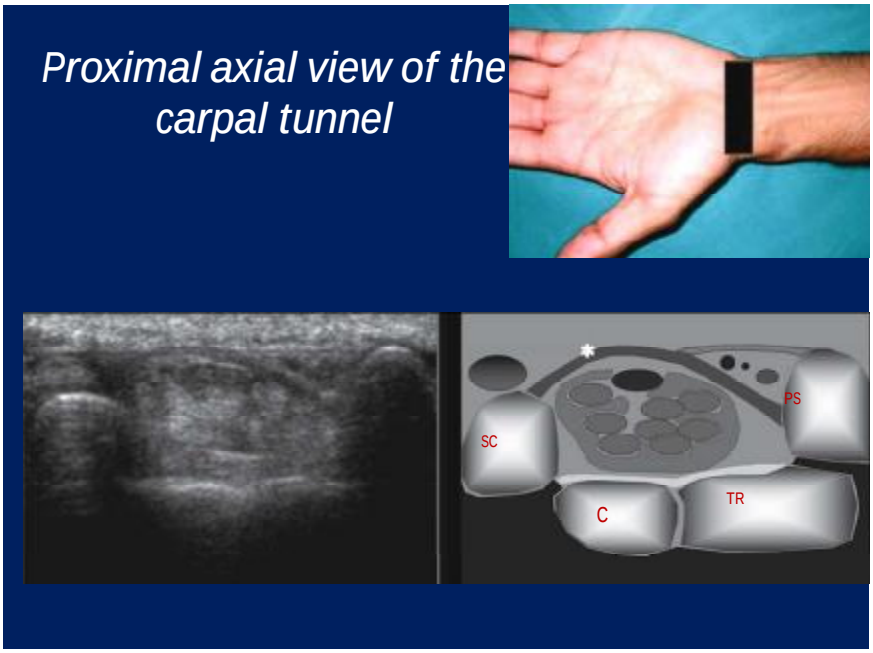


Fig 4 : DISTAL AXIAL VIEWOF CARPAL TUNNEL

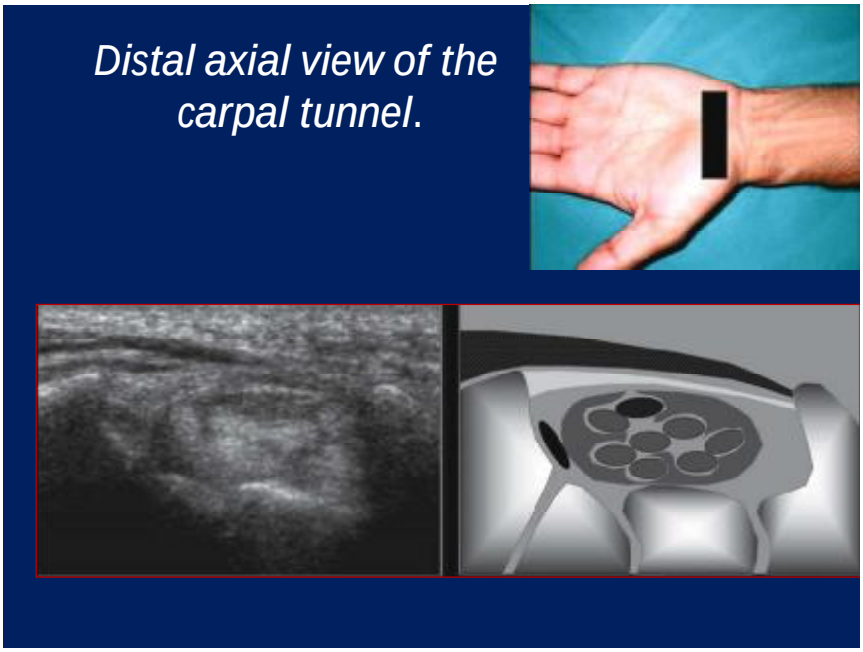
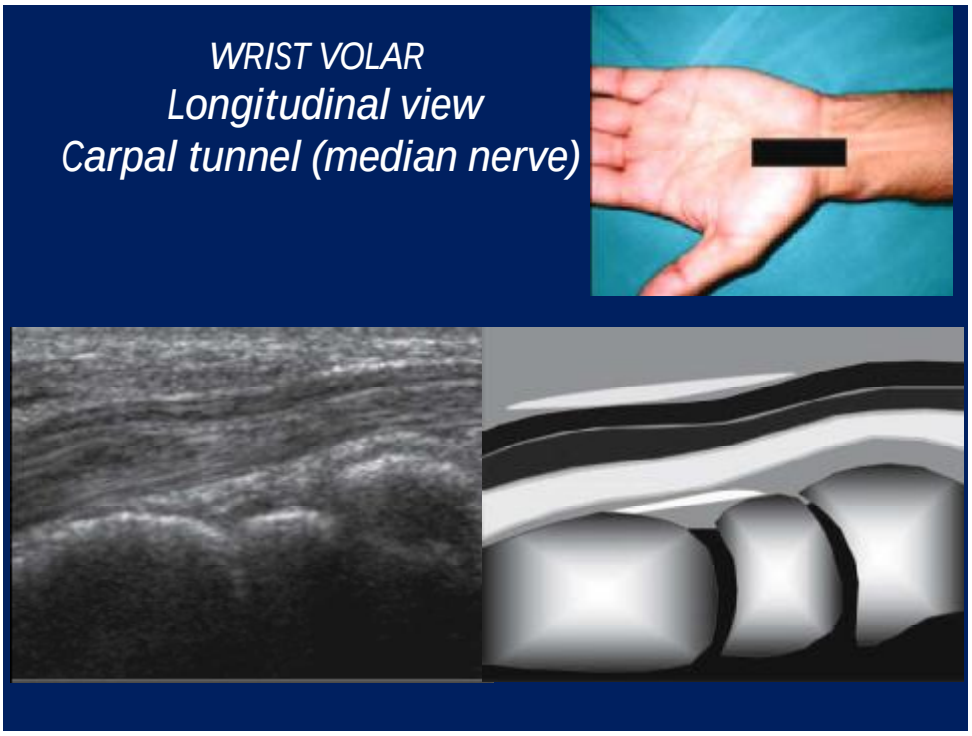
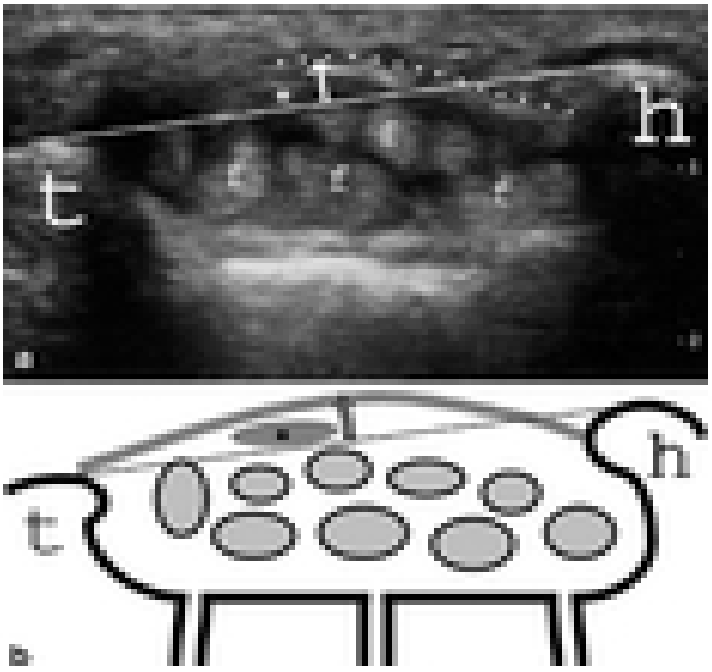


Fig 5 : LONGITUDINAL VIEW OF MEDIAN NERVE IN CARPAL TUNNEL





MEASUREMENT OF PALMARBOWING OF FLEXOR RETINACULUM

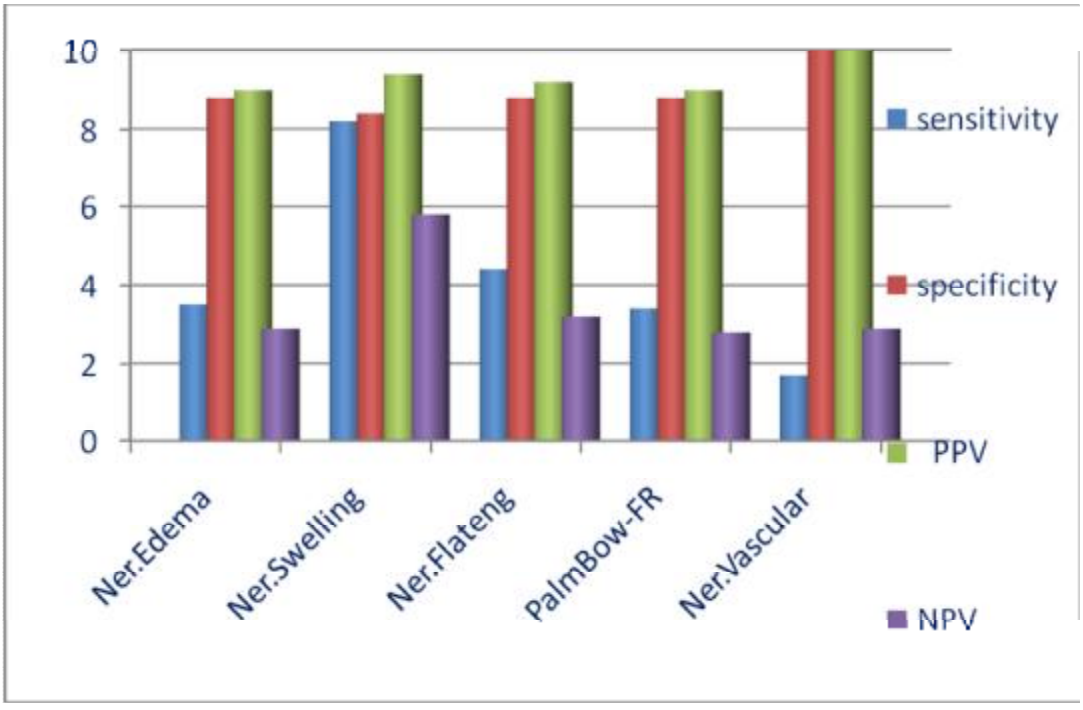
Fig 6 : SIEMENS ACUSON ANTARES ULTRASOUND SYSTEM

Fig 7. Sonographic Technique

Table showing Detectability of Sonographic Criteria Indicating Carpal Tunnel Syndrome in Comparison with NCS

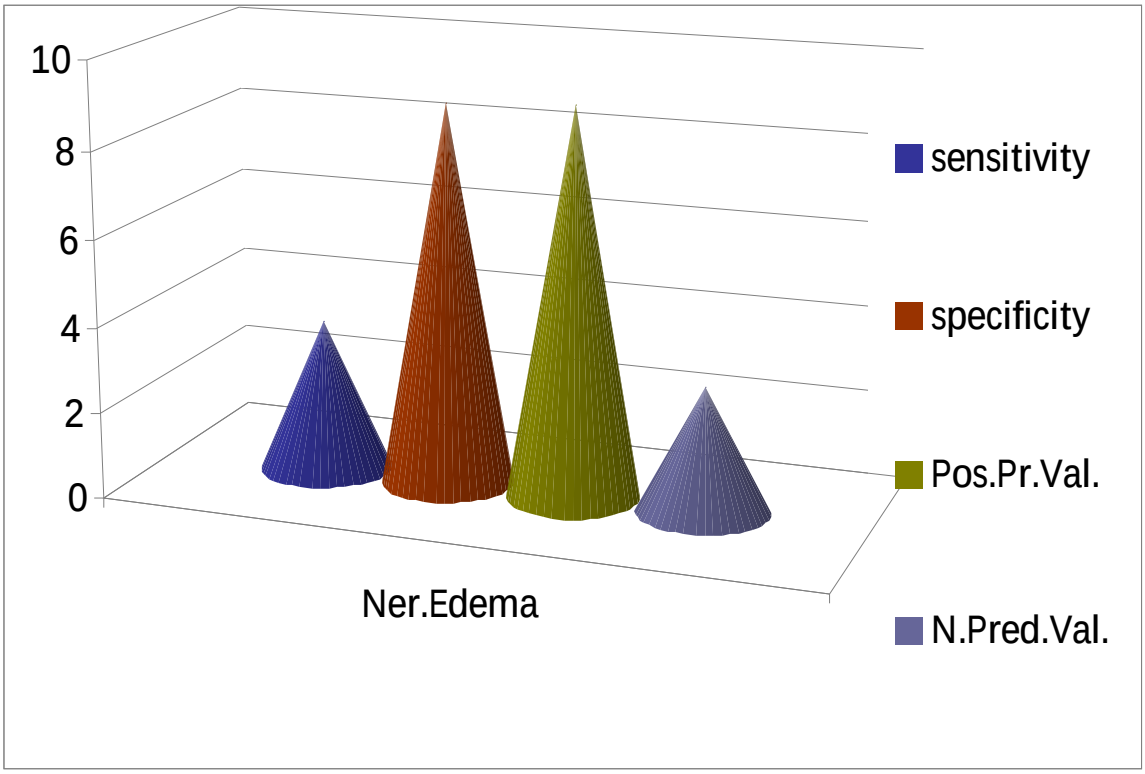
SONOGRAPHIC PREDICTORS	Sensitivity (%)	Specificity (%)	Positive predictive value(%)	Negative predictive value(%)
Nerve Edema	**35%**	**88%**	**91%**	**29%**
Nerve Swelling	**82%**	**84%**	**94%**	**58%**
Nerve Flattening	**44%**	**88%**	**92%**	**32%**
Palmar Bowing – Flex.Ret.	**34%**	**88%**	**90%**	**28%**
Nerve Vascularity	**17%**	**100%**	**100%**	**29%**

Sensitivity, Specificity, PPV and NPV Of Sonographic Criteria In Analysing CTS



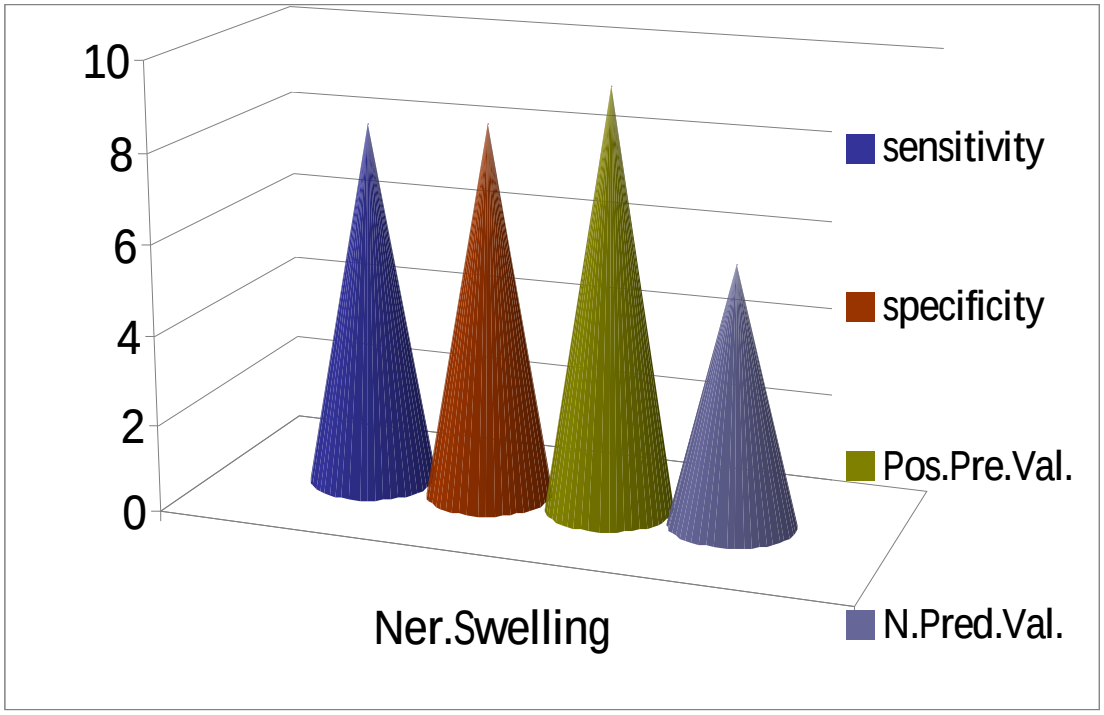
SENSITIVITY, SPECIFICITY, PPV AND NPV OF NERVE EDEMA

SONOGRAPHIC PREDICTORS	*Sensitivity (%)*	*Specificity (%)*	*Positive predictive value(%)*	*Negative predictive value(%)*
Nerve Edema	**35%**	**88%**	**91%**	**29%**



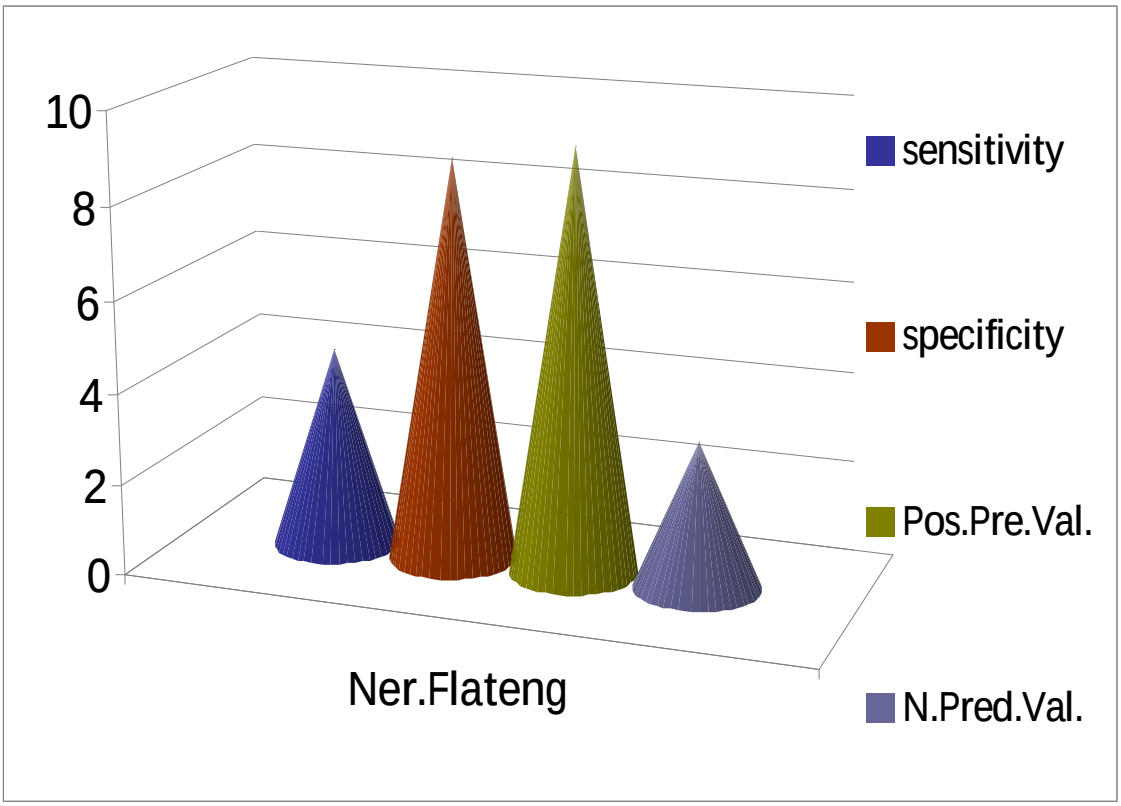
SENSITIVITY, SPECIFICITY, PPV AND NPV OF NERVE SWELLING

SONOGRAPHIC PREDICTORS	*Sensitivity (%)*	*Specificity (%)*	*Positive predictive value(%)*	*Negative predictive value(%)*
Nerve Swelling	**82%**	**84%**	**94%**	**58%**



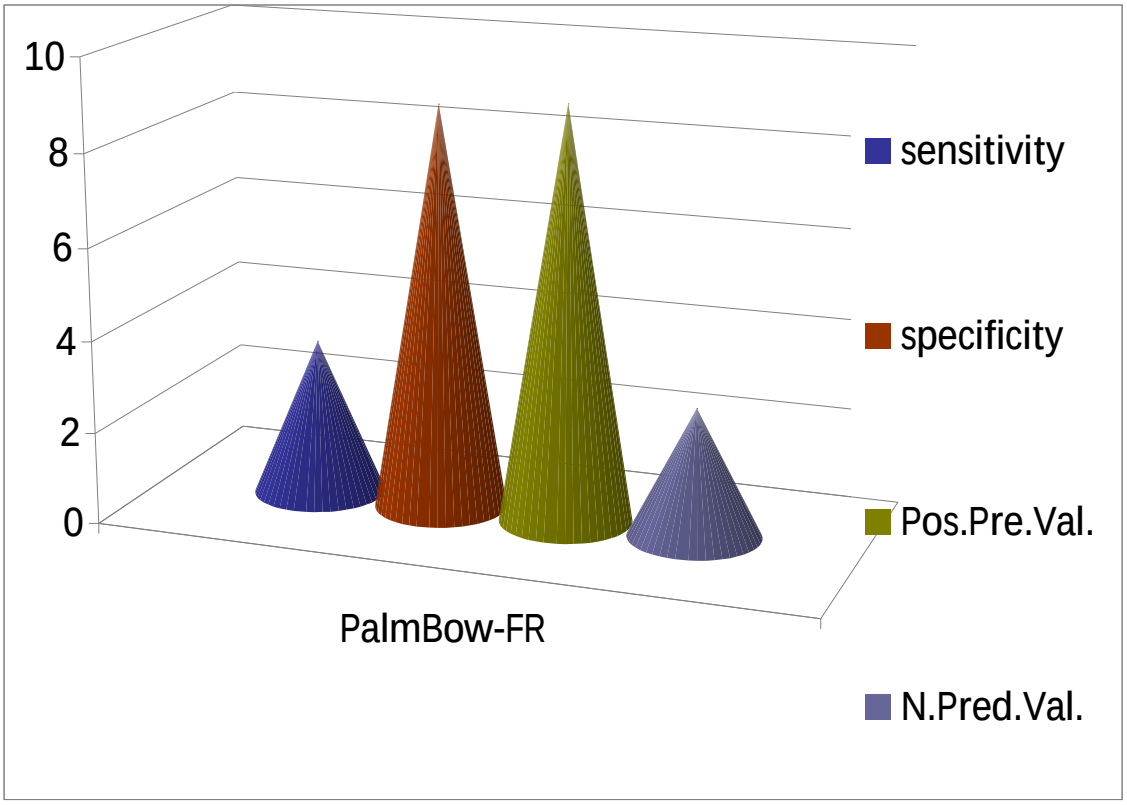
SENSITIVITY, SPECIFICITY, PPV AND NPV OF NERVE FLATTENING

SONOGRAPHIC PREDICTORS	*Sensitivity (%)*	*Specificity (%)*	*Positive predictive value(%)*	*Negative predictive value(%)*
Nerve Flattening	**44%**	**88%**	**92%**	**32%**



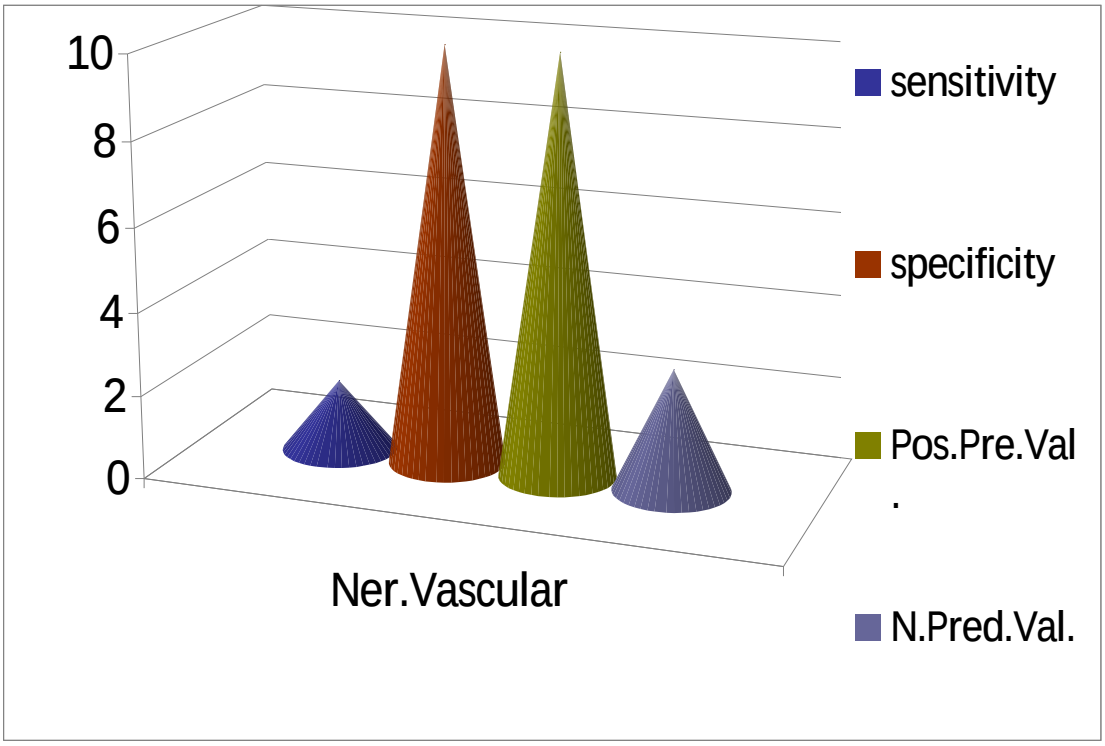
SENSITIVITY, SPECIFICITY, PPV AND NPV OF PALMAR BOWING OF FLEXOR RETINACULUM

SONOGRAPHIC PREDICTORS	*Sensitivity (%)*	*Specificity (%)*	*Positive predictive value(%)*	*Negative predictive value(%)*
Palmar Bowing – Flex.Ret.	**34%**	**88%**	**90%**	**28%**



SENSITIVITY, SPECIFICITY, PPV AND NPV OF INTRANEURAL VASCULARITY.

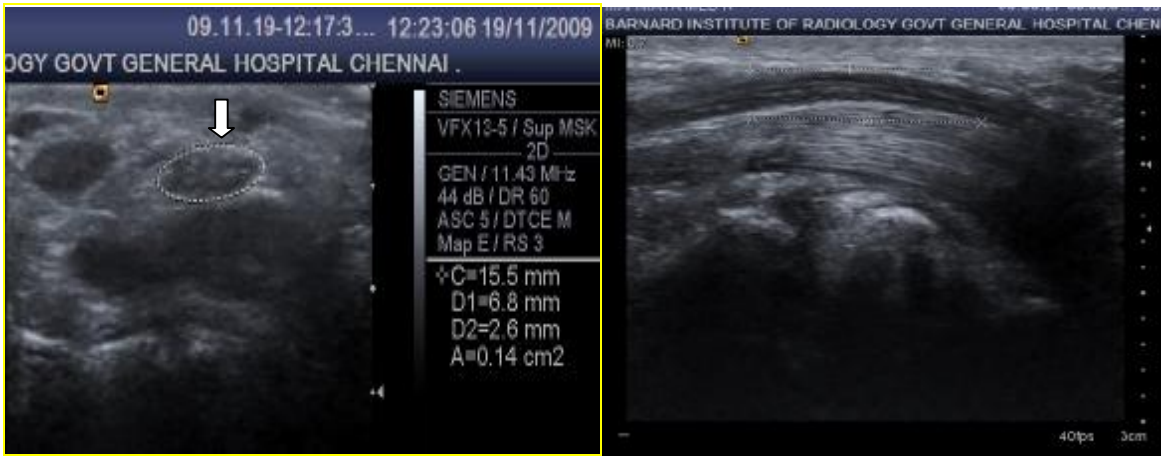
SONOGRAPHIC PREDICTORS	*Sensitivity (%)*	*Specificity (%)*	*Positive predictive value(%)*	*Negative predictive value(%)*
Nerve Vascularity	**17%**	**100%**	**100%**	**29%**



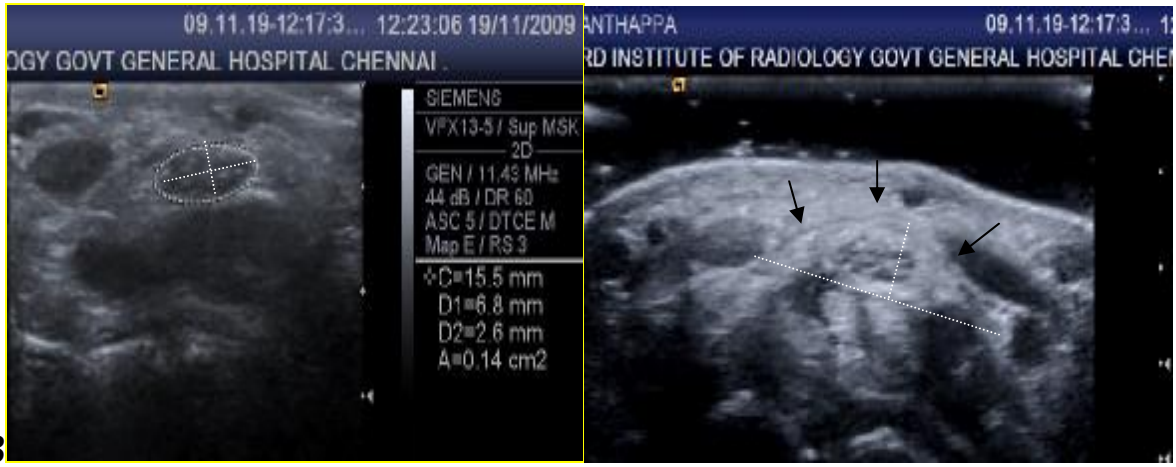
CASE1 : 64-year-female with nerve conduction studies proven carpal tunnel syndrome.

A and **B,** Gray-scale sonogram at carpal tunnel depicts swelling of median nerve (white *arrow*) with cross-sectional area of 0.14cm^2 in addition to nerve edema (longitudinal section) and palmar bowing of flexor retinaculum (*arrows*).**C,** Transverse color Doppler sonograms at carpal tunnel inlet show no intraneural vasculature .

A



B



C

CASE2: 57years female with positive nerve conduction study and clinical symptoms of Carpal tunnel syndrome **A** and **B,** Gray-scale sonogram at carpal tunnel depicts palmar bowing of flexor retinaculum (*arrows*)with no median nerve swelling (white *arrow*) of cross-sectional area of 0.07cm^2. **C,** Transverse color Doppler sonograms at carpal tunnel shows intraneural vasculature.

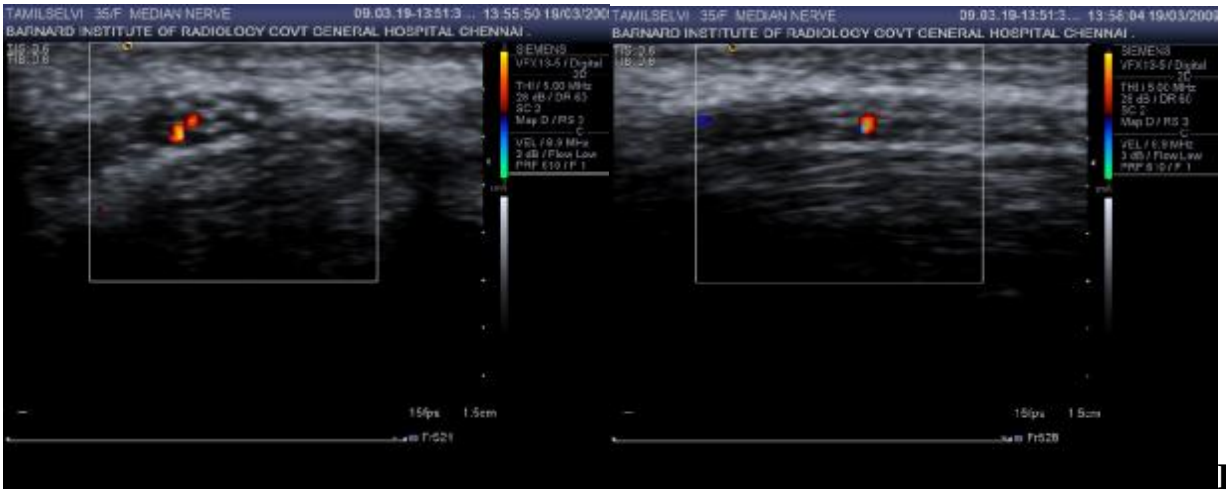
A

B

C

CASE3: 35years female with positive nerve conduction study and clinical symptoms of Carpal tunnel syndrome. **A,** Gray-scale sonogram at carpal tunnel depicts median nerve swelling (white *arrow*) of cross-sectional area of 0.12cm^{2}with flattening and no palmar bowing of flexor retinaculum (*arrows*) **B ,**Transverse and longitudinal color Doppler sonograms at carpal tunnel shows intraneural vasculaturity.

A

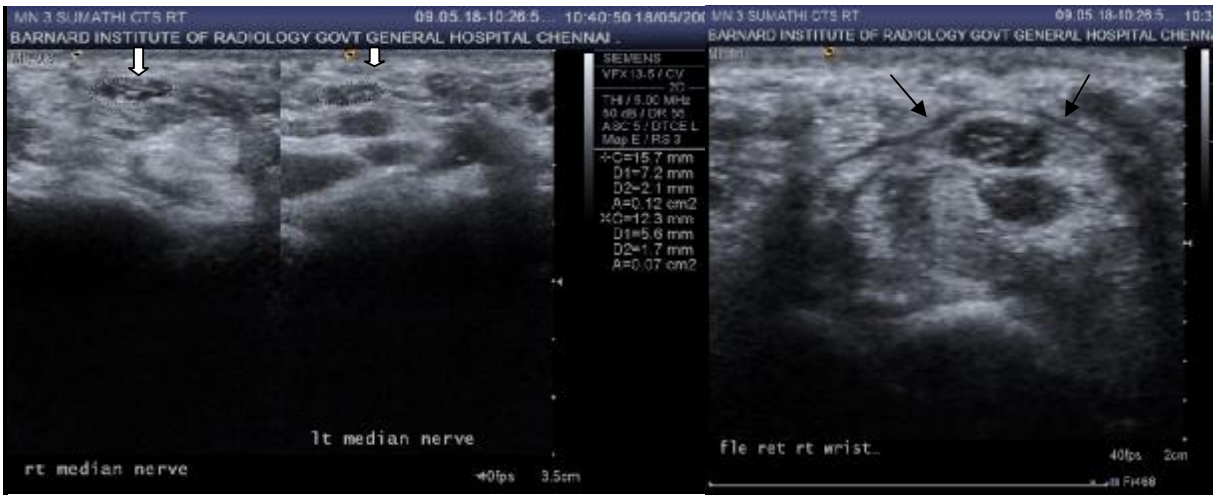


B

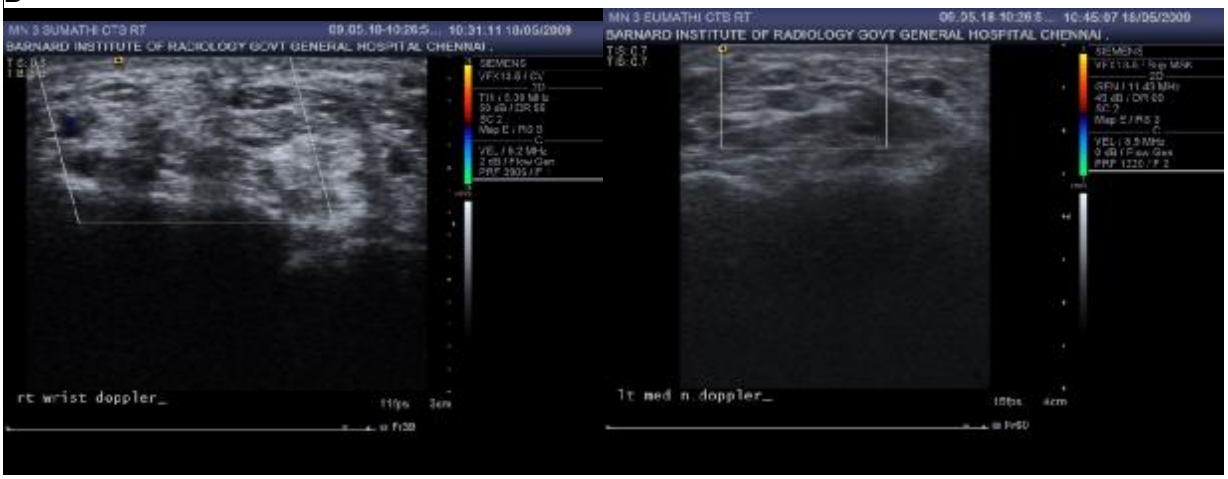
CASE4 : 40-year-female with nerve conduction studies proven carpal tunnel syndrome of both wrists.

A, Gray-scale sonogram at carpal tunnel depicts swelling of right median nerve (white *arrow*) with cross-sectional area of 0.12cm^2 in addition to nerve flattening and palmar bowing of flexor retinaculum (*arrows*) of right median nerve. Left median nerve shows no swelling and no palmar bowing of flexor retinaculum **B ,** Transverse color Doppler sonograms at carpal tunnel show no intraneural vasculature of both median nerve.

A



B



CASE5: 54years male with positive nerve conduction study and clinical symptoms of Carpal tunnel syndrome **A** and **B,** Gray-scale sonogram at carpal tunnel depicts median nerve swelling (white *arrow*) of cross-sectional area of 0.13cm^2 and nerve flattening with no palmar bowing of flexor retinaculum (*arrows*). **C,** Transverse color Doppler sonograms at carpal tunnel shows no intraneural vasculature.

A

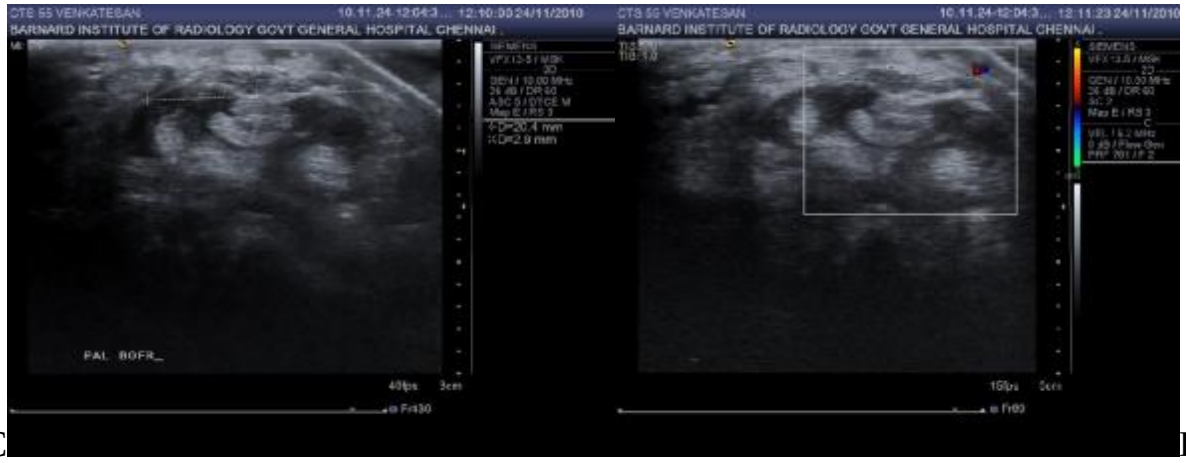
B

C

CASE 6: 54years male with positive nerve conduction study and clinical symptoms of Carpal tunnel syndrome

A, B and **C** Gray-scale sonogram at carpal tunnel depicts median nerve swelling (white *arrow*) of cross-sectional area of 0.12cm^2 , nerve flattening and palmar bowing of flexor retinaculum (*arrows*). Also there is mild peritendinous fluid collection in carpal tunnel s/o tenosynovitis**,** **D,**Transverse color Doppler sonograms at carpal tunnel shows no intraneural vasculature.

A B



C D

CASE 7 : 25year-female with negative nerve conduction studies for carpal tunnel syndrome
A and **B,** Gray-scale sonogram at carpal tunnel shows no swelling with cross-sectional area of 0.08cm^2 (white *arrow*) and no palmar bowing of flexor retinaculum(*arrows),mild* nerve flattening of median nerve noted. **C,** Transverse color Doppler sonograms at carpal tunnel show no intraneural vasculature.

A

B

C

CASE8 : 43-year-female with nerve conduction studies proven carpal tunnel syndrome of both wrists.

A, Gray-scale sonogram at carpal tunnel depicts swelling of right median nerve (white *arrow*) with cross-sectional area of 0.14cm^2 in addition to nerve flattening ,nerve edema (**C**)and palmar bowing of flexor retinaculum of right median nerve. Also there is peritendinous fluid collection(blue arrow) in carpal tunnel s/o tenosynovitis

B Left median nerve shows no swelling(CSA-0.09CM^2)and no palmar bowing of flexor retinaculum and **D,** Transverse color Doppler sonograms at carpal tunnel show no intraneural vasculature of both median nerve.

A 

B

C

D 

CASE9: 33-year-female with nerve conduction studies proven right carpal tunnel syndrome and NCS negative of left CTS.

A, Gray-scale sonogram at carpal tunnel depicts swelling of right median nerve (white *arrow*) with cross-sectional area of 0.13cm^2 in addition to nerve flattening and palmar bowing of flexor retinaculum (*arrows*) of right median nerve. **B** Left median nerve shows no swelling(white *arrow*) and no palmar bowing of flexor retinaculum **C,**Transverse color Doppler sonograms at carpal tunnel show no intraneural vasculature of both median nerve.

A C

B C